Art. IV.—*The Palæontological Sequence of the Lower Ordovician Rocks in the Castlemaine District.*

Part I.

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(With Plate I.).

[Read 11th May, 1916].

Victorian economic geology, more particularly in so far as it is concerned with the origin and occurrence of auriferous lodes, is so intimately associated with the folding of palæozoic strata and the resulting problems, that any reliable guide to the order of superposition of the various beds is likely to be useful. The absence of conglomerates and other well defined bands deprives geologists of benchmarks that would be of assistance in working out the folding of the rocks in localities where good exposures are wanting. Recognition of the part certain favourable beds play in the enrichment of lodes, more particularly at Ballarat, and to a lesser extent at Bendigo, Daylesford, and elsewhere, has accentuated the importance of obtaining a working knowledge of the stratigraphical relations of the rocks of these localities. In the absence of this knowledge even expert opinion is liable to err. Mr. E. J. Dunn states that "the South Eureka rocks appear to be well up in the Castlemaine zone . . . Spring Gully appears to be still higher. . . . The Fryerstown belt is in the Castlemaine zone."[1] These three localities seem on palæontological evidence to be all Upper Bendigonian, and hence much more favourable for quartz mining than the above makes them appear. The researches of Dr. T. S. Hall and others have resulted in the subdivision of the Victorian Lower Ordovician rocks into four series—Lancefield, Bendigo, Castlemaine and Darriwil, in ascending order. The relations between the three lower series are clearly shown in several areas, and are generally known, but, though the Darriwil series is recognised as somewhat above the Castlemaine series, its exact stratigraphical position has remained in doubt. This paper includes, among other efforts, an attempt to co-ordinate the Castlemaine and Darriwil series.

1 Dunn, E. J., Rec. vol. iii., part ii., Geol. Surv. Victoria.

I. Area.

The area over which these observations extend includes about 100 square miles. Its approximate boundaries are, on the north and east the granite massif of Mount Alexander, on the west the Muckleford Creek, and on the south a line drawn from Strangways through Tarilta, Glenluce, and Fryerstown to the Elphinstone Tunnel on the Melbourne to Echuca railway.

II. Previous Workers.

A. R. C. Selwyn[1] as early as 1853 made a section of the beds from the Campaspe to the Loddon along a line passing through Mounts Alexander and Tarrengower.

The late Dr. T. S. Hall[2] in a paper to this Society on the Geology of Castlemaine (1894) shows that the differences between the graptolites of the various outcrops are due to the stratigraphical relation of the beds. From the palaeontological evidence he was able to demonstrate their succession and outline six zones. He also gives a general account of the geology of the district. His paper deals particularly with the area to the south and the east of the town of Castlemaine and forms the basis for all later palaeontological work on this area. The general lines of the classification of the graptolite zones indicated in this paper have since been independently confirmed in other districts. The writer during the years 1912-1915 examined all but three or four of the outcrops previously visited by Dr. Hall, and is able to attest the accuracy of the deceased worker's observations. One who has traversed the rough hills around Castlemaine can thoroughly appreciate the painstaking and accurate work which, without the aid of present-day facilities for travelling, Dr. Hall carried out over twenty years ago. The difficulties in the way have resulted in a scientifically fertile field lying idle for more than two decades.

Mr. W. Baragwanath[3] deals with portion of the area in Memoir 2 of the Geological Survey of Victoria. Axial lines are plotted and a section given showing the succession of the strata. The section is evidently based mainly on observed dip. No particular section line is marked on the map, but the section appears to be along a line from Forest Creek through Quartz Hill to Gaol Hill. If so, it errs in not showing a ge-anticline on the Cemetery Reef where the lowest

1 Geology and Mineralogy of the Mt. Alexander Goldfield, Parl. Papers, 1853-4, vol. ii., et Q.J.G.S., vol. x.

2 Proc. Roy. Soc. Victoria, vol. vii. (n.s.), 1894.

3 Castlemaine-Chewton Goldfield. Mem. 2 Geol. Surv. Vic.

beds north of Forest Creek occur. These beds are on the Wattle Gully horizon, and *Didymograptus bifidus* is found at more than one place along the line. The beds to the east are only Middle Castlemainian, while, further east still, on the east side of Forest Creek, Upper Castlemaine graptolites are found.

Mr. H. Herman,[1] in a brief description of the lodes of Castlemaine, gives a section, apparently based on the one just mentioned, and marks on it three zones—viz., Bendigo, Wattle Gully, and Castlemaine. The above criticism applies to this section also. From a palaeontological standpoint both are in error in showing the central beds too high in the series.

Besides these papers there are others dealing incidentally with the district. These, and also Dr. Hall's other papers on graptolites, will be referred to when necessary.

III. Characteristics of Fossiliferous Rocks.

Graptolites are widely distributed throughout the district and have been found at more than one hundred localities. They occur in slates of every colour. The slates of the *Oncograptus* zone often bear a distinct resemblance in colour and texture to certain Upper Ordovician rocks, particularly those exposed along the Saltwater River near Digger's Rest, but in the state of our knowledge no importance should be attached to lithological resemblance. With isolated exceptions graptolites in this district are found only in slates or fine mudstones which as a rule are less common than sandstones. Limestone of Ordovician age is absent. Quartz grit ridges and bands of coarse sandstone occur, but, though it may be possible to do so, no attempt has so far been made to correlate them. One is therefore compelled to rely entirely on the fine sediments, often so cleaved that the fossils are difficult to break out. This will be the more readily understood when it is realised that the cleavage is rarely parallel to the lamination and often crosses it at an angle of 30° or more. It is therefore difficult or impossible to obtain a good idea of the facies of some outcrops, though if the beds are Upper Castlemaine *Didymograptus caduceus* may often be recognised along the broken edge of a slab.

IV. Limitations of Mathematical Stratigraphy.

It is almost unnecessary to say that no method of working out the problems of rock folding in an area is more accurate than measure-

1 Economic Geology and Mineral Resources of Victoria. Bull. 34, p. 24, Geol. Surv. Vic.

ment and plotting by strike, dip, and pitch, and if it were always possible to employ this method, palaeontology, as it is used here, would lose much of its value. Anyone who has worked over a considerable area of country where exposed sections are few, knows how really limited, under such circumstances, the mathematical method is, and, where sections do occur, how interdependent the mathematical factors are. In the constantly varying angle of dip according to the portion of an anticline or syncline exposed at the surface, anything like accuracy is impossible and with the long low curves of pitch one is at a complete loss. Added to these difficulties, there is at Castlemaine the problem of overturned beds which occur in the east of the area and render valueless observations of dip obtained in shallow cuttings. These are often vitiated also by surface drag or warp diagonal to the directions of dip and strike, which gives a false dip.

V. Stratigraphical Value of Graptolites.

In the slates of Castlemaine there is sufficient evidence to be obtained of the life history of many species of graptolites to afford a fairly complete set of zonal fossils. The evidence is cumulative and not isolated, and that of the many species that together make up a facies is rarely at fault. From a zonal standpoint Dr. Hall[1] has used the Dichograptidae—*Tetragraptus approximatus* (Nich.), *T. fruticosus* (J. Hall), and *Didymograptus bifidus* (J. Hall)—with conspicuous success in his classification of the Lower Ordovician rocks of Victoria. Miss Elles[2], regarding the rise and fall of a genus and species, observes that "a certain resemblance of thecal characteristics, number of thecæ in a given space, inclination of ventral and apertural margins to the axis of the stipe, and the amount of thecal overlap may be regarded as (a) of genetic origin and therefore (b) of systematic importance; and further, that a natural group with relatively few stipes was evidently developed from multiramous forms, so that of the usually accepted classification the Dichograptidae are highly important chronologically." There seems no doubt that the gradual progression from multiramous to simpler forms is world wide. At Castlemaine *Clonograptus* is common in the lower beds, and *Tetragraptus* and *Goniograptus* are more common in the lower than in the higher beds. *Diplograptus* occurs infrequently in the middle beds, but becomes more com-

1 Recent advances of our knowledge of Victorian Graptolites and elsewhere.

2 Graptollte Fauna of the Skiddaw Slates. Q.J.G.S., vol. 54 (1898), p. 529 ff.

mon later, while *Trigonograptus*, *Oncograptus*, *Lasiograptus*, and *Glossograptus* appear still later. The Upper Ordovician and Silurian graptolites are quite distinctive. Only the broadest outline seems possible at present, and conclusions drawn from observations on one side of the world may not be applicable to conditions on the other. For example, Elles, Wood and Ruedemann[1] all agree in deriving *Dichograptus octobrachiatus* from *Loganograptus logani*. In Victoria, as Dr. Hall[2] has pointed out, the order of occurrence is reversed, for while *D. octobrachiatus* is found in Upper Bendigo beds, *Loganograptus* is Upper Castlemainian. Differences such as this in the distribution of genera make one hesitate to generalise.

VI. Dr. Hall's Classification of Castlemaine Graptolites.

The following classification is that given in Dr. Hall's paper on the Geology of Castlemaine.[3] The zones are arranged in descending order as there set out.

1. Zone of *Loganograptus logani*.
2. Zone of *Didymograptus caduceus*. (Victoria Gully Beds.)
3. *Phyllograpto-caduceus* zone.
4. Burns' Reef beds. (*Phyllograptus typus*, with no predominant associates.)
5. Zone of *Didymograptus bifidus*. (Wattle Gully Beds.)
6. Zone of *Tetragraptus fruticosus*.

The facies of each zone is not given in detail, though it is briefly discussed. In another place Dr. Hall[4] states that "*Phyllograptus typus* long persists and is survived a short time by *P. angustifolius*. Specimens of *Diplograptus* appear in the higher beds but not apparently in the lower. A species of *Clonograptus* occurs in the lower beds, but soon disappears. *Loganograptus logani* puts in an appearance in the highest zones, and ranges into the Darriwil series."

VII. Proposed Revised Classification.

The table recorded below[5] shows the classification proposed. The beds are arranged in descending order and Dr. Hall's numbering is retained to render comparison easier. Beds above the Castlemaine series are prefixed with the letter "A."

1 Graptolites of New York, I. N.Y. Mus. Mem. 7 (1894), table op. p. 554.
2 Graptolite-bearing Rocks of Victoria. Geol. Mag. (n.s.), Dec. iv., vol. vi. (1899), pp. 442-443.
3 Geol. of Castlemaine. Proc. Roy. Soc. Victoria, vol. vii. (n.s.), 1894, p. 88.
4 Graptolite-bearing Rocks, op. cit., p. 443.
5 Vide p. 55.

GRAPTOLITE ZONES OF THE CASTLEMAINE DISTRICT.

Series and Division.	No. of bed on map.	Locality of Typical Development—Castlemaine.	Zonal Fossils.	Other Characteristic Fossils.
Darriwil (W. J. Harris and T. S. Hall)—				
Upper (or Darriwil of Dr. T. S. Hall)	A	Guildford-Strangways Road	Glossograptus, sp. indet. Trigonograptus Lasiograptus (absence of C. morsus)	Diplograptus, cf. angustifolius. „ gnomonicus, sp. nov. Didymograptus caduceus. „ v-deflexus, sp. nov.
Middle	A	Guildford-Strangways Railway	C. morsus Trigonograptus (absence of Oncograptus)	Diplograptus gnomonicus, sp. nov. Didymograptus caduceus. „ v-deflexus, sp. nov. Phyllograptus, sp.
	A	Chinamen's Creek	Cardiograptus morsus Oncograptus Trigonograptus	Diplograptus gnomonicus. Didymograptus caduceus. „ v-deflexus, sp. nov. Phyllograptus, sp.
Lower	A	Woodbrook Road	Oncograptus upsilon Trigonograptus (absence of C. morsus)	Didymograptus caduceus. „ v-deflexus. Phyllograptus, sp. Didymograptus caduceus, var. manubriatus
Castlemaine—				
Upper	1	McKenzie's Hill	D. caduceus (max. develop.) Loganograptus logani	Didymograptus, spp. Diplograptus, spp.

GRAPTOLITE ZONES OF THE CASTLEMAINE DISTRICT (*Continued*).

Series and Division.	No. of bed on map.	Locality of Typical Development—Castlemaine.	Zonal Fossils.	Other Characteristic Fossils.
Castlemaine—				
Upper (*cont.*)	2	Victoria Gully	D. caduceus (absence of P. typus)	Dichograptus, cf. octonarius. Diplograptus, spp.
Middle	3	Victoria Gully East	D. caduceus (small) P. typus	Dichograptus, cf. octonarius. Clonograptus, sp.
	4	Burns Reef	P. typus (absence of D. bifidus)	As in bed 3
Lower	5	Wattle Gully	D. bifidus (absence of T. fruticosus)	P. typus. P., cf. angustifolius. G. crinitus. D. octobrachiatus T. pendens. Clonograptus, spp. T. similis.
Bendigo—				
Upper	6	Daphne Reef	T. fruticosus (3-branched)	As in Wattle Gully Beds, and G. macer. G. thureaui.
Middle	7	South Fryerstown Race	T. fruticosus (4-branched)	G. macer. T. pendens T. similis. P. cf. typus. Didymograptus latus.

Only forms of fairly certain identity are given in this table; more extended search will probably extend the range of some of the species. The horizontal Didymograpti present difficulties which minimise their suitability for use as zonal fossils, though it is probable that detailed work with them will lead to instructive results. Other forms such as *T. serra* and *T. quadribrachiatus* appear to range through all zones. *T. serra* is very common in some of the beds of the Darriwil series as constituted in this paper, *Goniograptus* is represented in the Middle Castlemaine beds by one specimen of a new species and only one specimen of *D. octobrachiatus* has been found in Victoria Gully beds. Only three specimens of *Triaenograptus*, T. S. Hall, are known, and only two of these were found in situ. The futility of using such species in an account of zonal distribution is obvious, and, with a view to simplicity, it has been thought better to give only the more useful species.

VIII. Classifications Compared.

It is apparent that this scheme of classification supplements the older one. The following notes on the two classifications will serve to show resemblances and differences:—

1. Beds of the Darriwil series, as previously constituted, have for the first time been recorded from the Castlemaine district.

2. The meaning of the term Darriwil has been extended so that in the Darriwil series are now included not only those beds referred to the Darriwil by Dr. Hall, but also previously unrecognised beds between these and the Upper Castlemaine (*Logano-caduceus*) zone. I at first constituted these beds a new series under the name "Yapeen," but I found later that apparently all these beds did exist in the Darriwil district, and it seemed advisable to retain that name for the series, thus giving it an extended meaning. This alteration involved many alterations in the text, but was made too late to enable the whole paper to be recast.

3. The Castlemaine series remains as described by Dr. Hall. The two zones of the Middle Castlemainian are not always distinguishable, and it was at first thought better to unite them. However, as Dr. Hall[1] after mature consideration separated them (they appear as one zone in an earlier paper), it was decided to make no change. The test for distinguishing them, "the comparative rareness of *D. caduceus*"[2] in the lower bed, is weak and not always applicable.

1 Geol. Castlemaine, op. cit.
2 Geol. Castlemaine, p. 70.

4. Bendigo beds lower than any described in the earlier paper have been recorded South of Fryerstown. In them occur *T. fruticosus* (4-branched form), and *D. latus* (T. S. Hall). Dr. Hall mentions the latter species as probably indicating Lower Bendigonian. This discovery has involved the division of the *T. fruticosus* zone into two—one characterised by the three-branched form, and the other by the four-branched. The question arises as to what differences should be tolerated in any one zone, for between the typical beds of these zones (placed with the lower zone in this paper), are beds containing three and four-branched forms. At Tarilta, Bendigo, and at one outcrop on the Fryers-Chewton Road, the three-branched form is found with *D. bifidus*, the zonal fossil of the succeeding zone. The same merging of zone into zone is present throughout all the series, and shows that any division of palaeontological development into stages must not be too arbitrary. While, therefore, a number of zones can be distinguished, yet between all of them are transitional beds which serve to link them. This will be again referred to in this paper.

IX. Stratigraphical Relations and Typical Sections.

To obtain a definite idea of the gradual change of facies at the various outcrops it is necessary to work across the area from east to west. If it were possible to travel in a straight line west from the Elphinstone Tunnel this would involve a walk of ten miles. An equally or even more instructive section could be made by starting south of Fryerstown and going east to Limestone Creek—a distance of some seven miles; but exposures along this line are less common. In either case the presence of gullies and the concealment of the bed rock by recent alluvium make it necessary to zig-zag and to piece together evidence obtained from north and south of the direct line. The pitch of the numerous small anticlines and synclines being unknown it is impossible to say what the dip will be north or south of any observed outcrop, the whole country having, as Dr. Hall[1] has pointed out, a resemblance to a troubled sea, wave succeeding wave in every direction. The surface "drag" of rocks on the east or west slopes of hills make surface indications of dip almost valueless. To add to the difficulty a dip may change from easterly to westerly without a syncline or an anticline having been observed. The sections included in this paper have therefore been made diagrammatic. This was the more necessary since west of Castlemaine comparatively few observations of dip can be made.

1 Geol. Castlemaine, p. 65.

(a) The Elphinstone Tunnel—Castlemaine Section.

This section for the first five miles is based mainly on the evidence of the cuttings on the Melbourne-Echuca Railway from the Elphinstone Tunnel (72 miles) to the 77-mile post south of the town of Castlemaine. The section for the next two miles is based on observations made on the hills south and south-west of Castlemaine. West of this in a direct line evidence is scanty. The graptolites of the railway cuttings have been described by Dr. Hall[1]. With the record of his observations I have rarely found it necessary to disagree, but, thanks to greater facilities for travelling, the opportunity has presented itself of filling in more detail. The rocks at the western entrance to the tunnel dip west owing to inversion. *Tetragraptus fruticosus* is to be found in a small drainage channel south of the railway, indicating the Upper Bendigonian horizon. The fine anticline mentioned by Dr. Hall[2] is now obscured by surface soil, but calculating its position, I paced west, and was fortunate in locating the "repeat" outcrop of *T. fruticosus* near the 72-mile post. The calculation was afterwards found to have been unnecessary as the anticline is clearly shown on the side of the road to the north of the line. The next observed graptolite beds occur in the second cutting. Here two bands of fossiliferous slate occur, and an anticline causes both to be repeated; while still another band occurs further west. All are Wattle Gully (*D. bifidus*) beds—Lower Castlemainian.

The next outcrop, a few chains east of the 73-mile post (all mile posts mentioned are those on the railway), has *Phyllograptus typus* associated with the small form of *Didymograptus caduceus*. *D. bifidus* is not found. The horizon is Middle Castlemainian. Just past the 73-mile post the large form of *D. caduceus* occurs, and since it again occurs along the line of strike less than half a mile to the south and is there associated with *Diplograptus* sp. and *Loganograptus logani*, I have felt justified in indicating this as Upper Castlemaine. Three chains further west of the mile post the same zone repeats, and about three hundred yards still further west *Oncograptus upsilon* may be found in light-coloured slates with a westerly dip, and a little further on *Trigonograptus*. These beds are best developed at the 73½-mile railway bridge. Here they are thick almost horizontal beds of blue slate—probably the corrugated trough of a geo-syncline. Fossils are common, but a very troublesome cleavage—common in nearly horizontal beds—makes extrac-

1 Geol. Castlemaine, op. cit.
2 Geol. Castlemaine, p. 66.

tion difficult, and specimens are poorly preserved. *Oncograptus upsilon* and varieties of *Didymograptus caduceus* occur as typical forms, and *Didymograptus v-deflexus* sp. nov. and *Trigonograptus* are also found. *Cardiograptus morsus*, nov. sp., is absent, which agrees with the evidence of other localities, and indicates that this form is characteristic of a higher horizon. *Oncograptus* occurs a little to the south on the same strike and in the creek bed half-a-mile to the north, and even north of this.

The next beds present some difficulty. Separated from the *Oncograptus* beds by recent deposits, but only 200 yards from them, typically Middle Castlemaine beds occur. *Phyllograptus typus*, J. Hall, and small forms of *Didymograptus caduceus*, being found in fair numbers in a narrow band of decomposed white slate. These beds also occur to the south, where they are succeeded on the west by Upper Castlemaine beds in the usual order. Along the railway the next beds are also Upper Castlemaine. As the evidence of other localities is very strongly against the Middle Castlemaine being within 600 feet of the *Oncograptus* beds, these Middle Castlemaine beds seem difficult to fit in. Faulting is apparently responsible for their juxtaposition. More than this statement the evidence does not warrant, but the common occurrence of slickensided faces and the experience of miners shows that faulting is common in these rocks. Between this outcrop and the 74-mile post Upper Castlemaine beds are found, and they are also well represented at the mile post. This zone again repeats, and then no fossils are found until Chewton is reached. Further search may reveal some, probably Middle Castlemaine, as such beds are exposed on the hills to the south and to the north (at Burns' Reef). Just past the Chewton Railway Station (75 miles) *D. bifidus* and *P. typus* re-appear on the summit of the Chewton ge-anticline on the strike of Dr. Hall's original Wattle Gully beds, Wattle Gully itself crossing the railway line immediately to the west. Higher beds—Middle Castlemaine—occur along the same strike at Quartz Hill north of the line, but southwards all the beds are either of the same horizon (Lower Castlemaine), or lower, as at Lost Gully (Daphne Reef) and Mount Eureka (The Monk), where Upper Bendigo beds outcrop. The Wattle Gully zone outcrops to the north in Cemetery Gully, and even further north in Dirty Dick's Gully. This is interesting, as the zone has seemingly never been previously recorded north of Forest Creek. At one spot a large variety of *D. bifidus*, with branches about 40 mm. in length, is found. The only other Castlemaine locality where it occurs is in Steele's Gully south of the

line. This northerly occurrence of *Didymograptus bifidus* marks the apex of a ge-anticline not shown in Messrs. Baragwanath or Herman's section. Several occurrences of *D. bifidus* between Chewton and 76½ miles indicate smaller anticlines. Near Aberdeen Hill, Middle Castlemaine beds are found, and then, after repetition, an ascending series of Upper Castlemaine between the Vincent Street bridge and the 77-mile post. The railway soon after this ceases to be of value, and the section has been worked out westward on less complete evidence. The most westerly occurrence of Middle Castlemaine beds noted in this locality is near New Chum Gully, though isolated outcrops may exist further west. With this exception, all graptolites found between a north and south line through the 77-mile post and the Harcourt-Campbell's Creek railway line are Upper Castlemaine.

So far the stratigraphical relations of the members of the Castlemaine series and some members of the Bendigo and a higher series, have been traced from the apex of a ge-anticline at the Elphinstone Tunnel exposing Upper Bendigo beds, through a syncline at 73½ miles, exposing beds containing *Oncograptus* and higher than the Castlemaine series, to the main apex of the Chewton ge-anticline exposing Wattle Gully (Lower Castlemaine) beds. These beds recur at intervals for about a mile, and then disappear under higher beds which rest on the western limb of this ge-anticline.

(*b*) *Water Race Section.*

Parallel to the whole length of the previous section and mostly within the same compass there is an almost complete section along the water race to the south. It is supplemented in part by outcrops along the ridge of hills between the race and the railway section already traversed in detail and by beds exposed south of the race on either side of the Chewton-Fryerstown Road.

Leaving the railway half way between the 72 and 73 mile posts, *Didymograptus bifidus* is first found, and after an unfossiliferous stretch, several Upper Castlemaine outcrops the first of which, as before mentioned, can be correlated with an outcrop on the railway. The beds then pass through Middle Castlemaine to Lower Castlemaine, several *D. bifidus* outcrops occurring between White Horse Gully and the Chewton-Fryerstown Road. From this road to the Monk the race is unfossiliferous, but at the Monk a small outcrop of the Bendigo series occurs, the beds on either side being still Lower Castlemaine. Between the Monk and the offtake of the South Campbell's Creek race

five outcrops yield *D. bifidus*, some also yielding a number of undescribed specimens. Another unfossiliferous stretch follows, but is in turn followed by the most prolific area in the district. In the area between Scott's Gully and New Chum Gully the outcrops are so numerous that they cannot well be shown on a map of small scale. The general succession from Middle to Upper Castlemaine is clear.

Sections Compared and Additional Data.

There are, then, in more or less detail, four lines of section along which the succession of beds from Upper Bendigo to Upper Castlemaine may be traced.

(a) That along the railway from Elphinstone Tunnel to Castlemaine, showing an ascent from Upper Bendigo to Upper Castlemaine and beyond, then a descent to Lower Castlemaine and a second ascent to Upper Castlemaine.

(b) That along the water race to the south, where the succession is the same, though more detailed.

(c) That along the hills between these two lines showing Middle and Upper Castlemaine beds.

(d) That east and west of the Chewton-Fryerstown Road, where the succession from the Upper Bendigo to Middle Castlemaine is well shown.

A fifth line along the South Campbell's Creek water race and hills from the Monk via Sebastopol Hill to Campbell's Creek shows an ascending series from Lower Castlemaine to Upper Castlemaine. From south of Fryerstown to the Limestone Creek the succession is from Lower or Middle Bendigo upwards, but an area between Guildford and Tarilta has not been examined. In addition a somewhat incomplete record is seen north of Forest Creek, and here the succession is the same. About the Vaughan-Tarilta "trap" area (Ba 80 and 81)[1] the beds pass from Upper Bendigo or transitional Wattle Gully (*T. fruticosus* and *D. bifidus*), to Middle Castlemaine as one goes west. The lowest beds in the district are those south of Fryerstown.

The evidence of all these sections is corroborative and supplementary, and, as they are parallel and contiguous, also cumulative. Few places offer more opportunity for checking one's work, and it is unthinkable that beds with a distinctive and foreign facies could exist between the Middle and Upper Castlemaine beds as distinguished by Dr. Hall and amplified here. The repetition of Middle and Upper Castlemaine beds to the east and west of Victoria

1 G.S. Vic., ¼ S., 15 S.W.

Gully especially leaves no room for doubt as to the succession of these beds.

X. Darriwil Series.

(As before stated, Dr. Hall's term Darriwil has been extended to include new beds.)

The stratigraphical position of the series, which has as its associated fossils *Trigonograptus*, sp., *Didymograptus caduceus* (Salter), *D. v-deflexus*, sp. nov., *Oncograptus*, spp., *Glossograptus*, sp., *Diplograptus gnomonicus*, sp. nov., and other forms as yet undescribed, is on the negative evidence afforded by the work of others and myself, above the Castlemaine series. The soundness of Dr. Hall's subdivision of the Castlemaine series, confirmed, as it is, by the work of Mr. T. S. Hart[1] at Daylesford and by my own at Castlemaine, permits of no other conclusion. With the exception of the outcrops mentioned (at 73½ miles), *Oncograptus* has not been found east of Castlemaine. To the west of the town the *Oncograptus* facies prevails, beds with *Oncograptus* or its associated forms being numerous and widespread. One of the most easterly outcrops is in a cutting on the Woodbrook Road near the north-west of the municipality of Castlemaine. The material taken from the cutting is very much decomposed and cleavage is troublesome. *Oncograptus upsilon*, T. S. Hall, is common, *D. caduceus* in most of its varieties is exceedingly common, and *T. serra*, Brong, is common. *Trigonograptus* is not uncommon, while *Diplograptus sp.*, and *Didymograptus v-deflexus*, sp. nov., are found. *Phyllograptus* does not seem to occur. *Diplograptus gnomonicus, sp. nov.*, may be present, but it is so delicate that even if it be present it is not likely to be found in the material available. Along the same line of strike the nearest beds are 1½ miles to the south, and are Upper Castlemaine. About 400 yards west of this Woodbrook Road locality another outcrop occurs in which *Phyllograptus* is common, and is there, as in some other parts of the district, and also at Steiglitz, associated with *Oncograptus*. Half-a-mile south of this second *Oncograptus* locality, and apparently on the same line of strike, fossils are to be found on the road east of the Sanitary Depot. A small excavation was made here and exposed beds that yielded *D. caduceus*, *Oncograptus upsilon* and *Trigonograptus* all in profusion. Further excavation would probably yield a larger variety. The species of *Trigonograptus* occurring in these beds is apparently not *T. wilkinsoni*, T. S.

1 Proc. Roy. Soc. Victoria (n.s.), vol. xx. (1907), quoted by Hall, T. S., A.A.A.S. (1909), p. 319.

Hall, but *T. ensiformis*, J. Hall. I doubt if I have ever found *T. wilkinsoni*. A specimen of *Phyllograptus* was found in a fragment of rock, but not in situ. West of this locality similar beds are found, but not being well exposed, their graptolites cannot be given in detail, though *Oncograptus*, *D. caduceus*, *Diplograptus gnomonicus*, sp. nov., *Didymograptus v-deflexus*, sp. nov., and one specimen of *Glossograptus* may be recorded.

To the south is the Military Rifle Range. On it uppermost Castlemaine beds may be seen with characteristic forms, including *D. caduceus* and *Loganograptus logani*. In these beds an occasional *Oncograptus* may be found, but it is extremely rare. About 400 yards to the west of the Range there is a cutting on the Maldon line exposing thick beds of blue slate badly cleaved. *D. caduceus* and *Oncograptus upsilon* were obtained here, and a few yards to the south, on a small race, *D. caduceus*, *D. forcipiformis*, and *Goniograptus speciosus*, T. S. Hall. Still going west and a little south, the next beds, 300 yards further, on McKenzie Hill, yield a collection of forms difficult to specify; the beds are typically Upper Castlemaine. A rare *Trigonograptus* or *Oncograptus* may be found, but by far the most common form is *D. caduceus* and its varieties. This is the bed taken as typical of the *Logano-caduceus* (uppermost Castlemaine) zone, but though *Loganograptus logani* is common here, it is rare at other outcrops in the district.

The only other places where *Oncograptus* has been found in close relation to a recognised zone are near Yapeen and south of Guildford, and at both these places the nearest beds are Upper Castlemaine. West of these outcrops other forms are found and will be described, but Lower and Middle Castlemaine forms are conspicuously absent.

The field relations of the Darriwil beds near Yapeen and at Guildford and Woodbrook seem to indicate a high horizon for them. Along the line of strike in every case where fossils have been found they have been Upper Castlemaine. Occasional *Oncograptus* forms are found in Upper Castlemaine beds, and, as will be shown, there is a gradual progression from Upper Castlemaine through the *Oncograptus* beds to the original Darriwil zone.

(b) Nature of Facies.

A consideration of the *Oncograptus* facies involves the question of the subdivision of the beds of the series. The Bendigo and Castlemaine succession has long been known, but, while the graptolites of these two series are widely distributed, our knowledge of

Darriwil forms has been limited to those from one or two outcrops in the Darriwil district. As well preserved specimens are rare, the Darriwil forms are more difficult to identify specifically than those of lower horizons. While it was known that the Darriwil series was characterised by species of "*Tetragraptus*, *Didymograptus*, *Loganograptus*, *Diplograptus*, *Climacograptus*, *Glossograptus*, *Trigonograptus*, *Lasiograptus*, and others not determined,"[1] its exact relationship to lower beds had remained obscure and fossils found in other localities had thrown little light on the point. The presence of *P. typus*, J. Hall, with *Loganograptus* and large *D. caduceus* at Steiglitz was puzzling[2], and an assemblage of Newham forms "suggested the presence of both Darriwil and Castlemaine series."[3] The country to the west of Castlemaine had never been critically examined, and it was known to contain much that was new to the graptolite succession. Difficult forms found by officers of the Geological Survey half a century ago were still undescribed, and the chance of clearing away certain anomalies was deemed possible. It took time to acquaint oneself with these new forms, but having done so their order of development soon appeared. It soon became apparent that the beds could not be called Upper Castlemaine without altering the meaning of the term, nor for the same reason could they be called Darriwil, without widening the meaning of the term. The beds spread over an area of more than thirty square miles at Castlemaine, probably over a greater area at Macedon and Woodend, and south of Steiglitz, and occur also at Ingliston, Melton, and probably at other localities, and three zones seem to be recognisable.

In the Darriwil district all zones seem to be represented, the Upper or typically Darriwil, on Sutherland's Creek (W.L.S. 1, ¼ S.), and the lower or *Oncograptus* zone at Steiglitz.

In view of this all the beds, as already described, have been included in an extended series, for which the term Darriwil has been retained, and of which the previously known Darriwil beds form, as already stated, the upper zone. If, therefore, in earlier work "Darriwil" is read as "Upper Darriwil," no confusion will arise.

The vertical distance between the Middle and Upper Darriwil zones should be capable of measurement at Guildford, and they merge into one another through transitional beds.

No zone above that of *Tetragraptus fruticosus* has such a distinctive and characteristic association of species as these Darriwil

1 Hall, T. S., Australian Graptolites. Fed. Hbk. of Aust., B.A.A.S. (1914), p. 291.

2 Ibid., Reports on Graptolites, II. Rec. Geol. Surv. Vic., vol. iii., part 3 (1914), p. 290.

3 Skeats, E. W., and Summers, H. S., Geol. and Petr. Macedon District. Bull. Geol. Surv. Vic. 24 (1912), p. 41. Quoted from Hall, T. S., Geol. Surv. Vict. Prog. Rept., IX. (1898), p. 126.

beds. *Trigonograptus*, *Didymograptus v-deflexus*, sp. nov., and varieties of *Didymograptus caduceus*, range through all the series. *Oncograptus upsilon*, T. S. Hall, and *Diplograptus*, spp. indet., characterise the lower beds, *Cardiograptus morsus*, gen. et sp. nov., the middle beds, and *Diplograptus gnomonicus*, sp. nov., ranges through the Middle and Upper beds. *Strophograptus trichomanes*, Rued., also occurs. While it is impracticable in this part of the paper to discuss details of structure, a few points which will be dealt with more fully in the second part may be briefly indicated.

(a) The close resemblance of the thecae of *D. caduceus*, *Oncograptus*, and *Cardiograptus*[1] indicating a probable line of development.

(b) The progressive development in form of rhabdosome from *D. caduceus* to the Dicranograptid structure of *Oncograptus* and the biserial (?) *Cardiograptus*. *Diplograptus gnomonicus* may represent further development in the direction of simplification, for, while I have provisionally included it in the genus *Diplograptus*, its affinities with that genus are doubtful (Plate I., figs. 5 and 6). It may be of interest to note its close resemblance to a form figured by Ruedemann[2] as *Phyllograptus anna*, J. Hall. While these figures are given as of a phylogenetic, or senile, form of *Phyllograptus*, they differ from a typical specimen of that genus in (1) the presence of only two stipes. (Unless the drawings are misleading, the stipes normally shown as dark ridges along the medial plane, are absent, but a virgula is shown instead). (2) The more rapid alteration of the angle of inclination of the thecae. This will be seen by contrasting figs. 28 and 30 with others on the same plate. Except for the somewhat greater width the two figures bear a striking likeness to *D. gnomonicus*, which is certainly not a *Phyllograptus*. Another case of resemblance which may be more than a coincidence is presented by juvenile forms of *Oncograptus* and *Cardiograptus*, which recall the form described by Ruedemann[3] as *D. caduceus*, Salter, var. *nanus* (Plate I., fig. 9). Did the tendency, which in America ceased at this mutation, continue further and lead to the development of *Oncograptus* and *Cardiograptus*? It would appear not unlikely, for the horizon on which these forms are found seems to be that of *Diplograptus dentatus* in North America.

1 Since this paper was written Mr. R. A. Keble has intimated that after a close examination of Cardiograptus he has recognised a third branch which was probably at right angles to those on the plane of the laminae. Such a habit infers a phyllograptid structure which was hinted at by the late Dr. Hall in a verbal communication to the writer.

2 Grap. N.Y., I., pp. 715-716, plate 15, figs. 28 and 30.
Ibid., p. 698, fig. 90.

3 Grap. N.Y., p. 698, fig. 90.

(*c*) *Stratigraphical Horizon.*

Such being the forms present little doubt would have arisen as to the stratigraphical position of the beds but for the presence of *Phyllograptus* and *Goniograptus* which in this district were thought to have disappeared in the Middle Castlemaine[1] beds. In New Zealand, however, *Phyllograptus* is recorded in association with typical Upper Castlemaine (zone 1) forms[2]. The discontinuity of its range is therefore not so great as appears at first. (See Note 2 infra.) A similar anomaly with *Phyllograptus* is recorded by Ruedemann[3], who in a table showing the range of different species records *P. augustifolius* for Beds 1, 2, 3, and 6 of the Deep Hill Series, while he omits it from Beds 4 and 5. No possible arrangement of the beds will make all genera range continuously, and it must be left to later work to supply an adequate explanation. The polyphylogenetic origin of *Goniograptus* may be held to lessen the importance to be attached to its occurrence. To place the Victoria Gully Beds above the Darriwil Beds—which would be necessary to provide a continuous range for *Phyllograptus*—would break the continuity of the range for several other genera—for example, *Loganograptus*, *Trigonograptus*, *Oncograptus*, and *Glossograptus*. The fauna of the original or Upper Darriwil beds seems good evidence that these forms have been correctly placed, unless we are to suppose that these Darriwil beds are themselves Middle Castlemaine, a theory which I do not think sufficiently well supported to need combating. The presence of at least three genera of the Diplograptidae indicates a high horizon.

(*d*) *The Evidence from Didymograptus caduceus* (Salter).

The evidence to be derived from the study of the development of *Didymograptus caduceus* seems to point to a high position for

1 Geol. Castlemaine, op. cit.

2 Bell, J. M., Parapara Subdivision, N.Z. Geol. Surv. (n.s.), Bull., No. 3.
The forms recorded are said to be from one horizon, *Tetragraptus*, *Didymograptus*, *Loganograptus*, *Climacograptus* and *Phyllograptus* occurring on the same slab.
Figures are given of the following species—the comments in parentheses are mine.
Rastrites (obscure fragments which may or may not belong to that genus).
Didymograptus extensus (several figures representing two or more species of horizontal *Didymograptus*).
Tetragraptus quadribrachiatus (T. Serra).
*Loganograptus octobrachiatus (*non *L. Logani* vel *D. octobrachiatus.* An identical form is found in Upper Castlemaine beds here).
Phyllograptus typus.
Dyplograptus sp.
Didymograptus caduceus (typically Upper Castlemainian (zone 1) form).
Climacograptus (doubtful identification).

3 Grap. N.Y., I., p. 506. (Bed 4 is omitted from the table throughout).

the Darriwil beds. Dr. Hall[1] states that in the Bendigo beds "*D. caduceus* is rare and small, and it is interesting to notice as we pass up through a long succession of rocks above these of Bendigo that it increases in relative numbers and at the same time attains a much larger size till it reaches its maximum near the horizon of the uppermost Castlemaine beds, where it crowds the rocks to almost entire exclusion of other forms. It then enters on the period of its decline, and is but sparingly represented by stunted forms at Darriwil, and perhaps ranges into the Upper Ordovician." Later Dr. Hall[2] expresses his doubt as to the occurrence of *D. caduceus* with *T. fruticosus*, and I have not found them together. With *D. bifidus*, *D. caduceus* is rare and small. In the Middle Castlemaine beds it is fairly common but small. In the Victoria Gully beds it is very numerous, and the specimens are larger than those of the lower beds. Here the rhabdosome is of horse-shoe shape, the stipes are of even width throughout, and a long nema is often present. In the McKenzie's Hill beds *D. caduceus* is even more common than in the Victoria Gully beds, where Dr. Hall[3] estimated it to comprise 80 per cent. of the fauna. In typical specimens from this upper zone the stipes diverge at the angle of about 330°, and the branches widen as they diverge and then narrow somewhat towards their distal extremities. The rhabdosome is now more like the letter V than U. In the beds west of McKenzie's Hill *D. caduceus* varies greatly, though it seems as if the maximum of variation is in the McKenzie's Hill beds. The stipes are longer than ever, but not so wide. Stipes measuring over 60 mm. in length are not at all uncommon. The forms of the two zones contrast in the same way as the tall thin-branched trees of a forest do with the sturdy, wide-spreading trees of the more open country. The contrast is not so great between the higher beds of the McKenzie Hill zone and the lowest *Oncograptus* beds. Measurements of twelve specimens on one slab from an outcrop near the Muckleford Railway Station, showed an angle of divergence varying from 315° to 335°, the average being 325°. Several of the specimens have stipes more than 60 mm. in length. *D. caduceus*, Salter var., *manubriatus*, T. S. Hall, and *D. forcipiformis*, Rued., both late derivatives of *D. caduceus*, are somewhat rare in the McKenzie's Hill beds, and more abundant in the western beds, being more common at some outcrops than at others. As Dr. Hall[4] noted, the thecal

1 Grap. Rocks of Vict., p. 443.
2 Recent Advances of our Knowledge of Victorian Graptolites. A.A.A.S. (1909), p. 319.
3 Geol. Castlemaine, p. 71.
4 Victorian Graptolites, Part IV. Proc. Roy. Soc. Victoria, xxvii. (n.s.), part i., 1914, p. 109.

characteristics of *Oncograptus* show its relation to *D. caduceus*, and it seems probable that *Oncograptus* and *Cardiograptus*, like *D. forcipiformis* and *D. caduceus var. manubriatus*, are also late derivatives of *D. caduceus*, and had a very limited range. Here, then, is the life history of *Didymograptus caduceus*. Originating when *D. bifidus* was flourishing in the Wattle Gully stage, or perhaps earlier, it outlived that form, and became fairly common in the Middle Castlemaine, as yet showing little if any increase in size. By the time the Victoria Gully stage was reached it had become by far the commonest species, and with favourable conditions reached its zenith in the McKenzie's Hill beds. The common fate of all genera and species now overtook it. It deployed in various directions giving rise to *Oncograptus*, *D. forcipiformis*, *Cardiograptus*, etc. It will be the purpose of the second part of this paper to attempt to show the phylogeny of these and other genera. If the Darriwil beds are placed anywhere but above the Castlemaine beds the development of *D. caduceus* becomes unintelligible.

(*e*) *Transitional Beds.*

Victorian graptolite zones are all based on the rise and fall of species. *T. fruticosus*, *D. bifidus*, and *D. caduceus* originated in that order, lived in association, and one by one disappeared, affording a basis for the subdivision of the rocks in which their remains are found. Dr. Hall[1] has shown how *T. approximatus*, Nich., occurring with Lancefield forms at Inglewood and Clarendon, and with Bendigo forms at Bendigo and in the Mornington Peninsula, indicates the highest beds of the Lancefield, or the lowest beds of the Bendigo series.

Now, *Oncograptus upsilon* and *Trigonograptus* occur similarly at Castlemaine. At McKenzie's Hill the majority of the forms are so characteristic of the Upper Castlemaine of Dr. Hall that I have taken them as typical of that zone—more typical even than McCoy's Barker Street beds, where *D. caduceus* is, on the whole, not so well developed. Yet at McKenzie's Hill *Oncograptus* and *Trigonograptus* are occasionally found, indicating the close proximity of the McKenzie's Hill beds to the Lower Darriwil series. At the Military Rifle Range *Oncograptus* is also found, though here again it is extremely rare, and the beds are typically Upper Castlemaine. The Rifle Range beds, as shown above, are found to be succeeded along their line of strike by *Oncograptus* beds, which, if one pre-

1 Recent Advances Vic. Graps., p. 319.

sumes the northerly pitch found elsewhere near Castlemaine, is what might be expected if the Lower Darriwil beds overlay immediately the Upper Castlemaine. In the same way, as *D. bifidus* succeeds *T. fruticosus*, *Cardiograptus morsus*, gen. et. sp. nov., is, at some localities, found with *Oncograptus upsilon*. Then *Oncograptus upsilon* disappears, and at Guildford beds containing *Cardiograptus morsus*, also contain *Diplograptus*, cf. *angustifolius*, and this latter form is common with Upper Darriwil forms in a neighbouring bed. This is also true of other undescribed forms.

(*f*) *Subdivisions.*

The manner in which the Upper Castlemaine beds merge into beds in which *Oncograptus* occurs has already been discussed. At each of the four outcrops mentioned, in which the nearest beds are Upper Castlemaine, *Oncograptus upsilon* occurs, and *Cardiograptus morsus* does not. If it were at all common in these beds sufficient exploration has been done at least at two of them to reveal it. *Cardiograptus morsus* has never been found in Upper Castlemaine beds. These facts seem to indicate that *Oncograptus upsilon* is representative of the lowest zone of the series. At Macedon, where the Lower Darriwil beds are well developed, *Cardiograptus morsus* appears to be absent, at any rate from some beds, if not from all.

At Castlemaine localities further west than those above mentioned *O. upsilon* and *Cardiograptus morsus* are found in association, both forms being common. At Guildford *O. upsilon* has not been found, though *Cardiograptus morsus* is common. This would suggest that *C. morsus* came in later than *O. upsilon* and outlived it, which is supported by the fact that on the Guildford-Strangways Railway the *Cardiograptus* beds occur both east and west of typically Upper Darriwil beds. These *Cardiograptus* beds contain at least one species, *D. cf. angustifolius*, otherwise restricted to the neighbouring Darriwil. The Upper Darriwil beds at Guildford contain *Loganograptus*, *Diplograptus cf. angustifolius*, *D. caduceus* (varieties), *Diplograptus gnomonicus*, sp. nov., *Trigonograptus*, *Lasiograptus*, *Glossograptus*, and *Didymograptus v-deflexus*, sp. nov. No genus found at the typical Upper Darriwil locality (W.L.S. 1, ¼ S., 19 S.W.) is wanting here, except *Climacograptus*, and even at Darriwil *Climacograptus* does not appear to be common, as an examination of slabs in the National Museum, Melbourne, failed to reveal any specimen of the genus. At Darriwil, also (W.L.S. 2 and W.L.S. 3) *Cardiograptus morsus* is found, but not near enough to W.L.S. 1 to render exact correlation possible. It is instructive to find that

there it also occurs apparently without *O. upsilon*, though the latter occurs without it further north, near Steiglitz, as already noted.

(*g*) *The Series in other Localities.*

Most of the localities from which, as far as the writer knows, Darriwil graptolites have been obtained, have already been mentioned. They may be summarised as under :—

(1) Between Castlemaine and Muckleford Creek, and south-west of Guildford. (Lower, Middle, and Upper).

(2) At Woodend (eight miles S.W. of Woodend) and Macedon. (Lower.) (They are well represented north of Old Gisborne township, and along the railway south of Macedon R.S.), and at Newham (Upper?).

(3) Near Ingliston, and perhaps at Coimadai and Melton (Lower).

(4) At Steiglitz (Lower).

(5) South of Steiglitz (W.L.S. 2 and W.L.S. 3, $\frac{1}{4}$ S., 19 S.W.), parish of Coole Bharguk (Middle), and at Darriwil (W.L.S. 1) (Upper).

XI. Summary of Conclusions.

The proposed revised classification is the outcome of a critical examination of a number of sections and localities in which the stratigraphical relations of the beds are those given in the stratigraphical table.

This stratigraphical table shows :—

(a) An agreement in general with Dr. Hall's subdivision of the Castlemaine series.

(b) A new series above the Castlemaine series and between it and including the Darriwil beds of Dr. Hall. This is described as the Darriwil series.

(c) A subdivision of this extended Darriwil series into three zones based on the rise and fall and the association of certain described species and new species (to be described in Part II. of this paper).

(d) A record of the Upper Darriwil series at Guildford.

The stratigraphical position, nature of facies, the evidence supplied by *D. caduceus*, and a list of localities where the Darriwil series is known to occur in other parts of the State of Victoria, have been given in more or less detail.

The country examined to obtain the evidence necessary to erect this new series comprises that already examined by Dr. Hall and a

considerable area outside it. The first section given in this paper differs in certain important respects from those of Messrs. Baragwanath and Herman, and the extent of favourable auriferous beds —those in the vicinity of the Chewton ge-anticline appear to be more auriferous than others—is increased.

Bendigonian beds some distance down in the series are shown to occur near Fryerstown, and the succession on every side of the "dome" clearly indicates the pitch.

A map showing the general arrangement of the beds and more than 150 localities visited is given.

Acknowledgments.

In conclusion, I wish to express my indebtedness to all who have assisted me. To the late Dr. T. S. Hall in particular I owe much for placing at my disposal literature and specimens in his possession and for an always kindly interest in my work. His death has deprived the scientific world of its greatest authority on Australian graptolites. Mr. F. Chapman, A.L.S., Palaeontologist of the National Museum of Victoria, has assisted me by elucidating the cryptic symbols on the old Geological Survey plans and by permitting me to examine more closely than would otherwise have been possible specimens collected by officers of the Survey now in the possession of the Museum. From Mr. H. Herman, Director of Geological Survey, and officers of the Mines Department of Victoria, I have received valuable assistance. The re-drawing of plans, etc., has been carried out by the latter in a manner far superior to anything I could have done personally. Mr. R. A. Keble, of the Mines Department, in particular, has been in touch with my work since its beginning, and, besides making many valuable suggestions, has been kind enough to read through the manuscript and assist in moulding it to a publishable form. Dr. Rudolf Ruedemann very kindly forwarded me, through the Smithsonian Institute, his monograph on the "Graptolites of New York," a work of the value of which it is unnecesary for me to speak. It is impossible in any list such as this to do justice in detail to all who have assisted, so I conclude by thanking collectively all who have helped me. For the accuracy of observations and conclusions contained in this paper and not ascribed to others I must hold myself personally responsible.

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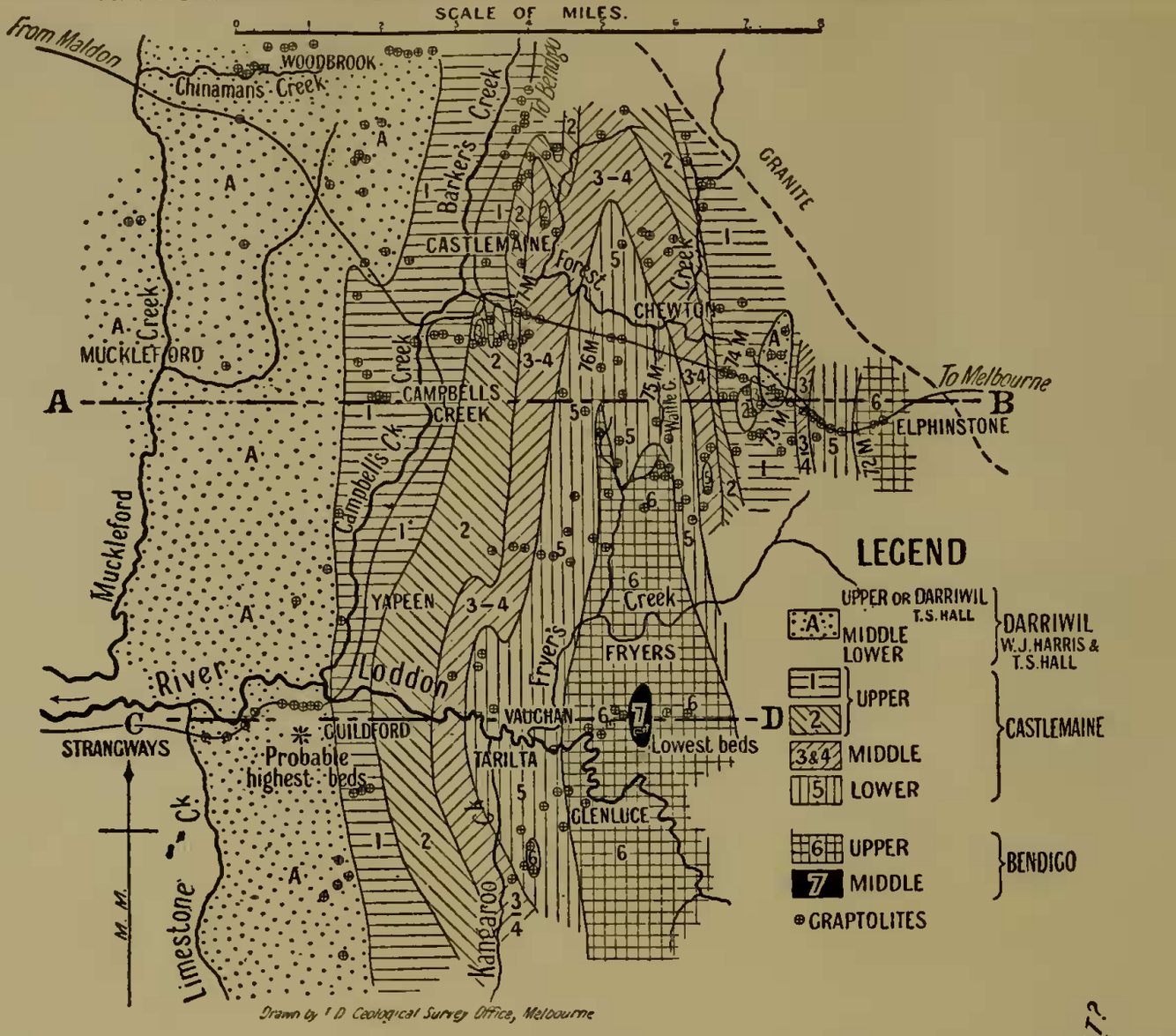
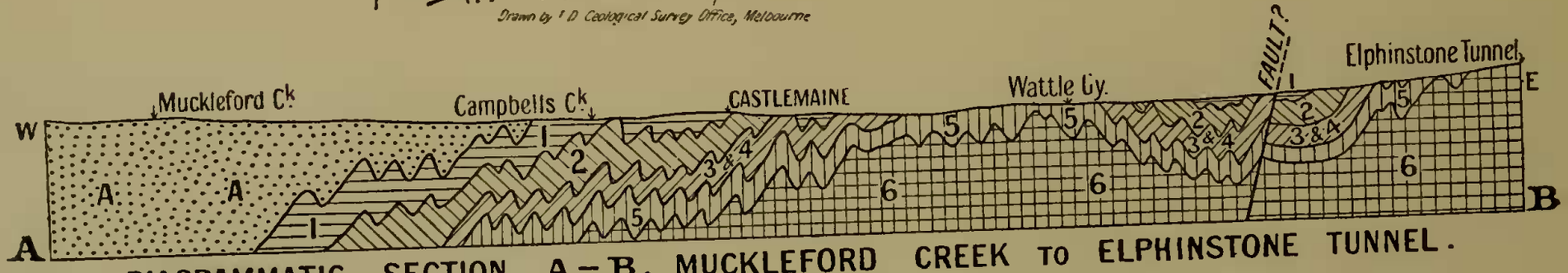
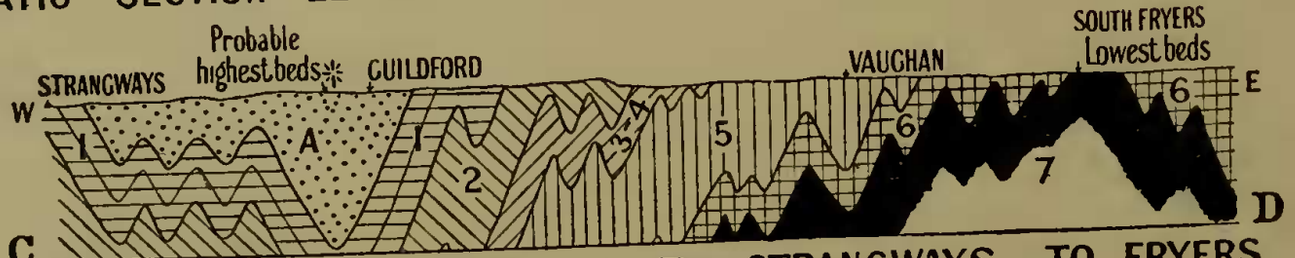
GEOLOGICAL PLAN OF CASTLEMAINE DISTRICT SHOWING APPROXIMATE BOUNDARIES OF GRAPTOLITE ZONES.





DIAGRAMMATIC SECTION A–B. MUCKLEFORD CREEK TO ELPHINSTONE TUNNEL.



DIAGRAMMATIC SECTION C–D. STRANGWAYS TO FRYERS